CHAPTER 2: INTRODUCTION TO ENGINEERING

2.1: INTRODUCTION TO ENGINEERING

The technology team; functions of the engineer; the engineering disciplines; education of the engineer; professionalism and ethics; professional and technical organizations; professional development; role and responsibilities of the engineer in Malaysian society; role of Board of Engineer Malaysia (BEM) in engineering education and professionalism; challenges of the future.

2.2: THE EDUCATION OF THE ENGINEER

- The desirable characteristics of an engineering student
- How programs are controlled
- The knowledge and skills required to be an engineer
- The descriptions of the main engineering disciplines

Engineers are taught and expected to solve problems which they have not experience or unheard yet.

Who is Responsible?

2.3: ENGINEERING STUDENT

- Characters
  - A strong interest in engineering, good in mathematics and science.
  - Logical thinking
  - Curiosity
  - Conclusion to solution of a problem
  - Focused
  - Available
  - Teachable

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2.4: ACCREDITATION BOARD

- All the engineering programs are accredited by the Accreditation Board in respective countries.
- In Malaysia all the engineering programs are controlled by the Nasional Accreditation Board (NAB) or Lembaga Accredidasi Nasional (LAN)
- The quality control of engineering programs is affected through the accreditation process. This are done through
  - Visitations
  - Evaluation of the syllabus, and
  - Written reports

Table No.1
Participating Bodies in the Accreditation Activity

American Academy of Environmental Engineers	AAEE
American Congress on Surveying and Mapping	ACSM
American Institute of Aeronautics and Astronautics, Inc.	AIAA
American Institute of Chemical Engineers	AICHE
American Nuclear Society	ANS
American Society of Agricultural Engineers	ASAE
American Society of Civil Engineers	ASCE
American Society of Engineering Education	ASEE
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.	ASHRAE
The American Society of Mechanical Engineers	ASME
Institute of Industrial Engineers, Inc.	IIE
The Institute of Electrical and Electronics Engineers, Inc.	IEEE
The Minerals, Metals & Materials Society	TMS
National Council of Examiners for Engineering and Surveying	NCEES
National Institute of Ceramic Engineers	NICE
National Society of Professional Engineers	NSPE
Society of Automotive Engineers	SAE
Society of Manufacturing Engineers	SME
Society for Mining, Metallurgy, and Exploration, Inc.	SME-AIME
Society of Naval Architects and Marine Engineers	SNAME
Society of Petroleum Engineers	SPE

THE EDUCATION OF THE ENGINEER*

In this lesson we will cover:

- The desirable characteristics of an engineering student
- How programs are controlled
- The knowledge and skills required to be an engineer
- The descriptions of the main engineering disciplines

1.0 INTRODUCTION

To keep pace with a changing world, engineers must be educated to solve problems that are as yet unheard of. A large share of this responsibility falls on the engineering colleges and universities. But the completion of an engineering program is only the first step toward a lifetime of education - the engineer, with the assistance of the employer and university, must continue to study.

An engineering education should provide a broad base in scientific and engineering principles, some study in the humanities and social sciences, and specialized studies in a chosen engineering curriculum.

2.0 DESIRABLE CHARACTERISTICS

Years of experience have enabled educators to analyze the performance of students in relation to abilities and desires they possess entering the engineering program. The most important characteristics for an engineering student can be summarized as follows:

1. A strong interest in, and ability to work with, mathematics and science.
2. An ability to think through a problem in a logical manner.
3. A knack for organizing and carrying through to conclusion the solution of a problem.
4. An unusual curiosity about how and why things work.

It should be noted that having these attributes is no guarantee of success in an engineering program. Simply a strong desire for the job has made successful engineers of some individuals who did not possess and of these characteristics; and, conversely, many that possessed them did not complete an engineering degree.

Focused - on their studies and their goal to be an engineer
Available - to learn and assist
Teachable - open minded to learn from others, especially their peers.

3.0 HOW PROGRAMS ARE CONTROLLED

In North America engineering programs are accredited by the Accreditation Board for Engineering and Technology (ABET) or the Canadian Engineering Accreditation Board (CEAB). These boards have as their purpose the quality control of engineering and technology programs offered in the United States and Canada. The basis of the boards is the participating professional groups. A listing of participating bodies is shown in Table No.1.

Table No.1
Participating Bodies in the Accreditation Activity

American Academy of Environmental Engineers	AAEE
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The American Society of Mechanical Engineers	ASME
Institute of Industrial Engineers, Inc.	IIE
The Institute of Electrical and Electronics Engineers, Inc.	IEEE
The Minerals, Metals & Materials Society	TMS
National Council of Examiners for Engineering and Surveying	NCEES
National Institute of Ceramic Engineers	NICE
National Society of Professional Engineers	NSPE
Society of Automotive Engineers	SAE
Society of Manufacturing Engineers	SME
Society for Mining, Metallurgy, and Exploration, Inc.	SME-AIME
Society of Naval Architects and Marine Engineers	SNAME
Society of Petroleum Engineers	SPE

The quality control of engineering programs is affected through the ***accreditation process***. The engineering profession (through ABET and CEAB) has developed standards and criteria for the education of engineers entering the profession. Through visitations, evaluations, and reports, the written criteria and standards are compared with the engineering curricula at a university. Each program, if operating according to the standards and criteria; receive accreditation to run the program. A maximum of six years may be given; fewer if some discrepancies appear.

Engineering schools vary somewhat in their emphasis on these areas, but the generic intent is to develop skills in the application of theory to practical problem solving and familiarity with engineering terminology.

Design is presented from a conceptual point of view to aid the student in creative thinking. Graphics develops the visualization capability and assists the student in transferring mental thoughts into well-defined concepts on paper.

With a strong background in mathematics and physical sciences, the student begins the study of engineering sciences - courses that are fundamental to all engineering specialties - electrical science, materials, mechanics and thermodynamics.

Specialized engineering courses vary with the engineering discipline and are usually taken in the third and forth years of a four-year program.

Most programs also allow students flexibility in selecting more general courses such as business, accounting, law, etc.

5.0 THE ENGINEERING DISCIPLINES

There are at least 24 fields of specialization in engineering now being offered by engineering institutions, and the list is growing as some disciplines are combined, or split, or merged with other faculties.

Seven of the individual disciplines will be discussed in the following section. They are:

1. Aerospace Engineering
2. Chemical Engineering
3. Civil Engineering
4. Electrical/Computer Engineering
5. Environmental Engineering
6. Industrial Engineering
7. Mechanical Engineering

Aerospace Engineering

Aerospace engineers study flight of all types of vehicles in all environments. They design, develop, and test aircraft, missiles, space vehicles, helicopters, hydrofoils, ships, and submerging ocean vehicles. The particular areas of specialty include aerodynamics, propulsion, orbital mechanics, stability and control, structures, design and testing.

Aerodynamics is the study of the effects of moving a vehicle through the earth's atmosphere. The air produces forces that have both a positive effect on a properly designed vehicle (lift) and a negative effect (drag). In addition, at very high speeds the air generates heat on the vehicle, which must be dissipated to protect crews, passengers, and cargo. Aerospace engineering students learn to determine such things as optimum wing and body shapes, vehicle performance, and environmental impact.

The operation and construction of turboprops, turbo and fanjets, rockets, ram and pulsejets, and nuclear and ion propulsion are part of the aerospace engineering student's study of propulsion. Such constraints as efficiency, noise levels, and flight distance enter into the selection of a propulsion system for a flight vehicle.

The aerospace engineer develops plans for interplanetary missions based on knowledge of orbital mechanics. The problems encountered include determination of trajectories, stabilization, rendezvous with other vehicles, changes in orbit, and interception.

Stability and control involves the study of techniques for maintaining stability and establishing control of vehicles operating in the atmosphere of space. Automatic control systems for autopilots and unmanned vehicles are part of the study of stability and control.

The study of structures is primarily involved with thin-shelled, flexible structures that can withstand high stresses and extreme temperature ranges. The structural engineer works closely with the aerodynamics engineer to determine geometry of wings, fuselages, and control surfaces. The study of structures also involves thick-shelled structures that must withstand extreme pressures at ocean depths and lightweight composite structural materials for high performance vehicles.

The aerospace design engineer combines all the aspects of aerodynamics, propulsion, orbital mechanics, stability and control, and structures into the optimum vehicle. Design engineers work in a team and must learn to compromise in order to determine the best design satisfying all criteria and constraints.

The final proofing of a design involves the physical testing of a prototype. Aerospace test engineers learn to use testing devices such as wind tunnels, lasers, strain gauges, and data-acquisition systems. The testing takes place in structural laboratories, propulsion facilities, and in the flight medium with the actual vehicle.

Chemical Engineering

Chemical engineers deal with the chemical and physical principles that allow us to maintain a suitable environment. They create, design and operate processes that produce useful materials, such as fuels, plastics, structural materials, food products, health products, fibres, fertilizers, etc. As our natural resources grow short, chemical engineers are creating substitutes or finding ways to extend our remaining resources.

The chemical engineer (in the development of new products, in designing processes, and in operating plants) may work in a laboratory, pilot plant, or a full-scale plant.

In the laboratory, the chemical engineer searches for new products and materials that benefit mankind and the environment. This is known as research engineering.

In a pilot plant the chemical engineer is trying to determine the feasibility of carrying on a process on a large scale. There is a great deal of difference between a process working in a test tube in the laboratory and a process working in a production facility. The pilot plant is constructed to develop the necessary unit operations to carry out the process. Unit operations are fundamental chemical and physical processes that are uniquely combined by the chemical engineer to produce the desired product. A unit operation may involve separation of components by mechanical means such as filtering, settling and floating. Separation may also take place by changing the form of a component - for example, through evaporation, absorption, or crystallization. Unit operations also involve chemical reactions such as oxidation and reduction. Certain chemical processes require the addition or removal of heat or the transfer of mass. The chemical engineer thus works with heat exchanges, furnaces, evaporators, condensers, and refrigeration units in developing large-scale processes.

In a full-scale plant, the chemical engineer will continue to 'fine tune' the unit operations to produce the optimum process based on the lowest cost. The day-to-day operational problems in a chemical plant, such as piping, storage, and material handling, are the responsibility of the chemical engineer.

Civil Engineering

Civil Engineering is the oldest branch of the engineering profession. The specialties within civil engineering include structures, transportation, sanitary and water resources, geotechnical, surveying, construction, and environmental.

Structural Engineers design bridges, buildings, dams, tunnels, and supporting structures. The designs include consideration of mass, winds, temperature extremes, and other natural phenomena such as earthquakes.

Construction Engineers work outside on the actual construction site. They become involved with the initial estimating of construction costs for surveying, excavation, and construction. They will supervise the construct-ion, start-up, and initial operation of the facility until the client is ready to assume operational responsibility. However, before any structure can be erected, a careful study of the soil, rock and groundwater conditions must be undertaken to ensure stability.

In addition to these studies, the **Geotechnical Engineer** analyzes building materials such as sand, gravel, and cement to determine proper consistency for concrete and other products. They analyze the properties and behaviour of soils and rock so that they can be used as engineering materials to be built upon or built with.

Civil Engineers in **transportation** plan, design, construct, operate, and maintain facilities that move people and goods. They make decisions such as where a freeway system should be located and describe the economic impact of the system on the affected public. They plan for growth of residential and industrial sectors of a city.

Surveying Engineers develop maps for any type of engineering project. For example, if a road is to be built through a mountain range, the surveyors will determine the exact route and develop the topographical survey that is then used by the transportation engineer to lay out the roadway.

The proper treatment and distribution of water, treatment of wastewater, and control of all forms of pollution concern **Sanitary Engineers** with maintaining a healthful environment.

The **Water Resources Engineer** specializes in the evaluation of potential sources of new water for increasing or shifting populations, irrigation, and industrial needs.

Electrical/Computer Engineering

Electrical/computer engineering is the largest branch of engineering. Because of the rapid advances in technology associated with electronics and computers, this branch of engineering is also the fastest growing. The areas of specialty include communications, power, electronics, measurement and computers.

We depend almost every minute of our lives on ***communication equipment*** developed by electrical engineers. Television, radios, telephones, and radar are common communications devices that we often take for granted.

The ***power engineer*** is responsible for producing and distributing the electricity demanded by residential, business, and industrial users throughout the world. The production of electricity requires a generating source such as fossil fuels, nuclear reactions, or hydroelectric dams. The power engineer may be involved with research and development of alternative generation sources such as sun, wind, and fuel cells. Transmission of electricity involves conductors and insulating materials. On the receiving end, appliances are designed by power engineers to be highly efficient in order to reduce both electrical demand and costs.

The area of ***electronics*** is the fastest growing specialty in electrical engineering. The development of solid-state circuits (functional electronic circuits manufactured as one part rather than wired together) has produced high reliability in electronic devices. ***Microelectronics*** has revolutionized the computer industry and electronic controls. Circuit components smaller than 1 micrometer in width enable costs and higher electronic speeds to be attained in circuitry. The microprocessor, the principal component of a digital computer, is a major result of solid-state circuitry and microelectronics technology. The home computer, automobile control systems, and a multitude of electrical application devices conceived, designed, and produced by electronics engineers have greatly improved our standard of living.

Great strides have been made in the control and measurement of phenomena that occur in all types of processes. Physical quantities such as temperature, flow rate, stress, voltage, and acceleration are detected and displayed rapidly and accurately for optimal control of processes. In some cases, the data must be sensed in a remote location and accurately transmitted long distances to receiving stations. The determination of radiation levels is an example of the electrical process called telemetry.

The impact of microelectronics on the computer industry has created a multibillion-dollar annual business that in turn has enhanced all other industries. The design, construction, and operation of computer systems are the task of computer engineers. ***Computer Engineers*** deal with both hardware and software problems in the design and application of computer systems. The areas of specialization include research, education, design engineering, scheduling, accounting, control of manufacturing operations, process control, and home computing needs.

Environmental Engineering

Environmental Engineers design and implement pollution abatement technologies to minimize the impact of human activity on the environment. They find employment in industry, municipalities, consulting firms, government agencies and research establishments.

Environmental Engineering is a multidisciplinary activity in which environmental engineers work closely with professionals from many other disciplines including biologists, chemists, economists, sociologists, lawyers, and others who play an integral role in defining and designing sustainable developments. The discipline of environmental engineering continues to grow and includes the following areas:

Water and Wastewater Treatment: Many water sources contain chemical or biological substances that make them unsuitable for human consumption. Municipal and industrial wastewaters contain substances that may be harmful if they are released to the environment without treatment. Environmental engineers design processes for removing undesirable elements from drinking water and wastewater.

Air Pollution Control: Fossil fuel combustion, industrial processes, and the wide use of petrochemical substances can release pollutants into the atmosphere that can have undesirable effects on human, animal, and plant life. Environmental Engineers implement processes and practices that prevent the formation of these pollutants, or capture and immobilize them.

Groundwater Flow and Contaminant Transport: Groundwater is a valuable source of drinking water but can be susceptible to contamination as a result of surface spills, leaking storage facilities and improper disposal practices. The study of groundwater flow and contaminant transport evaluates the physical and chemical processes that govern the movement of groundwater and various contaminants below the ground surface.

Solid and Hazardous Waste Management: Modern society generates large quantities of household, industrial, commercial, and institutional waste. Some of these wastes are classified as hazardous because they pose a substantial danger to human, animal, and plant life. Environmental Engineers implement processes and practices that minimize the amount of solid waste and dispose of it in a safe way.

Environmental Impact Assessment: Most industrial activity and application of technologies have an impact on the environment. Environmental Impact Assessment is the management tool used to delineate and quantify the impact of engineering projects on the environment. Environmental Engineers carry out impact assessments on a wide variety of projects that assist in environmental planning and decision-making.

Radioactive Waste Management: Use of radioactive materials (in power generation, etc) results in radioactive products and residuals that need to be properly managed and disposed of to prevent any potential harm to the biosphere. Environmental Engineers are involved in the development of chemical processes and engineered barriers for the long-term isolation of radioactive residuals.

Industrial Engineering

Industrial Engineering covers a broad spectrum of activities in organizations of all sizes. This field is concerned with the design, improvement, and installation of integrated systems of people, materials, and equipment as well as the informational and economic factors, which are major elements of engineering systems.

The principal efforts of industrial engineers are directed to the design of **production systems** for goods and services. For example, when the design of a product is completed, industrial engineers establish the manufacturing sequence from the point of bringing the materials to the manufacturing centre to the final step of shipping the assembled product. Industrial engineers develop a production schedule, oversee the ordering of standard parts, develop a plant layout for production of non-standard parts, and perform a cost analysis for all phases of production.

As production is ongoing, industrial engineers will perform various studies, called **time and method studies**. Which assist in optimizing the handling of material, the shop processes, and the overall assembly line. Depending on the size of the organization, the Industrial Engineer may specialize in one area of the plant or he/she maybe involved in all the plant activities.

The study of **human factors** is also an important area of Industrial Engineering. In product design, for example, Industrial Engineers involved in fashioning automobile interiors study the comfort and fatigue factors of seats and instrumentation. In the factory, they develop training programs for operators and supervisors of new machinery or for the new assembly-line operators.

With the rapid development of **computer-aided manufacturing (CAM)** techniques and of **computer-integrated manufacturing (CIM)**, the industrial engineer will play a large role in the factories of the future.

Mechanical Engineering

Mechanical Engineering originated when people first started to use levers, ropes, and pulleys to multiply their own strength and to use wind and falling water as a source of energy. Today mechanical engineers are involved with all forms of energy utilization and conversion, machines, manufacturing materials and processes, and engines.

Mechanical engineers utilize ***energy*** in many ways for our benefit; such as in refrigeration systems, heating systems, ventilation systems, and in heat exchangers. They are also involved in research in solar, geothermal, and wind energy sources, along with research to increase the efficiency of producing electricity from fossil fuel, hydroelectric, and nuclear sources.

Machines and mechanisms used in all forms of manufacturing and transportation are designed and developed by mechanical engineers. Examples in the area of transportation include automobiles, airplanes, tractors, trains, etc. Other examples include automated machinery and robotics (a rapidly growing area of mechanical engineering), lathes, milling machines, grinders, drills, etc. (in manufacturing), sorting devices, typewriters, staplers, and mechanical engineering background and a vivid imagination.

In order to drive the machines, a source of ***power*** is needed. The mechanical engineering is involved with the generation of electricity by converting chemical energy in fuels to thermal energy in the form of steam, then to mechanical energy through a turbine to drive the electric generator. Internal combustion devices such as gasoline, turbine, and diesel engines are designed for use in all areas of transportation. The mechanical engineer studies engine cycles, fuel requirements, ignition performance, power output, cooling systems, engine geometry, and lubrication in order to develop high-performance, low-energy-consuming engines.

The engines, machines, mechanical devices, etc., that are designed by mechanical engineers require many types of ***materials*** in their construction. ***Material science*** deals with the behaviour of engineering materials.